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ABSTRACT

It is suggested that the potential contributions research and development activities can make to the improvement of educational practice are far from fully realized for a variety of reasons. Researchers overlook problems teachers consider important, teachers are skeptical of proposals from external groups, and researchers and teachers lack a mutual appreciation of their problems. It is advocated that practitioners and researchers work together, and examples are cited of gaps in research and development efforts that limit the comprehensiveness of current knowledge of the systems designed to improve science education. (Author/PB)

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Integrating Research, Development, Dissemination and Practice in Science Education

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I believe it is generally obvious that the potential contributions research and development activities can make to the improvement of educational practice are far from fully realized. Among the factors contributing to this large gap between the possible and the actual are two major ones. There is no generally accepted comprehensive conception of the dynamics of the various parts that make up research, development, communications and practice in American education; and these parts are not functionally integrated. They are not even loosely coupled.

Where People Learn About Science

Most commonly, when discussions of science education take place the focus is on school and college courses. Yet, in fact, both children and adults acquire their notions about science from experiences in all sectors of their lives. The attitudes and beliefs of parents, friends, and other respected adults are influential. The mass media, particularly TV, are the source of much information or misinformation, as well as stimulating or dampening interests and affecting attitudes. Libraries and museums are important teachers for some people. Schools and colleges have a major responsibility for stimulating and guiding the science learning of children and youth but they provide only part of the learning experiences of most people, and in many cases, only a minor part. In seeking to improve science education, the larger environment needs to be examined and potentials for development explored. Very little research and and development has been focused on the learning outside of schools and colleges.

How Teachers View Research

Even though many R and D activities involve schools, it is still true that classroom teachers generally do not expect to get help on their problems from researchers or the results of research. This attitude arises from the teacher's preoccupation with the particular difficulties he or she is encountering which do not seem to be of interest to researchers, and from experiences with methods, materials and devices that were introduced with great expectations but failed to help the teacher accomplish what had been hoped.

In our highly decentralized educational system, the teacher is most directly accountable to the local authorities and to parents. As professionals, teachers feel a sense of responsibility to meet the expectations of the professional group with which they identify, but the standards are

those of colleagues, not of scientists or educational researchers. Parents and boards of education are more likely to judge teachers by the way discipline is handled and by comparative scores on standard tests than they are by the quality of science teaching.

The importance teachers attach to student discipline should not be overlooked in designing learning systems. In most classrooms, the teacher is responsible for the instruction of one or more groups of 25-30 students, usually active, not passive persons. The management of a class to enable attention to be focused on the desired learning, and to assure that every student is actively involved is a matter of great concern to almost all teachers. This problem has been overlooked by many developers of methods, materials, and devices for science education.

Another factor which has helped to produce a skeptical or resistant attitude of teachers toward advice and recommendations from outside the local school group has been the continuing efforts of pressure groups to get their special interests into the curriculum. Some of these special interests are widely known like the anti-evolutionists, air-age education, physical fitness, drug and alcohol prevention, and prayers. There are many others that try to influence teaching that are not so well-known. Some of the groups are well-intentioned, but the course of study cannot have the necessary cumulative effect if new pieces are being forced into it without a careful reappraisal of the whole. Because teachers recognize the dangers of responding to outside pressures asking them to tinker with the curriculum, many have developed an attitude of skepticism and rejection of all proposals from external groups. Unless they perceive the new ideas or materials as helping them with their problems, they have little interest in trying to apply the ideas or use the materials.

The individual teacher usually welcomes assistance with his or her particular problems, but not with problems that may exist elsewhere. Unfortunately, because research seeks generalizable, if possible, universal explanations for puzzling phenomena many educational researchers and developers have considered educational problems as universals. For example, in the 1960s, programmed materials were developed for use both in elementary and secondary schools on the assumption that a common problem was the lack of carefully sequenced instructional materials. Several centers were established, some supported by public funds and others by educational publishers to produce instructional materials systematically designed to furnish step-by-step guidance of student learning. Later, when these programs were evaluated and the results compared to the learning of students who used the traditional type of textbooks and supplementary materials, it was found that only a minor fraction of the students learned more when using programmed materials. Most of these were the so-called "slow learners". The majority of the students were not appreciably aided by the careful step-by-step sequencing. In fact, some of the more rapid learners appeared to do less well with programmed materials than with additional instructional materials. One can conclude that there are students who benefit by the use of programmed materials but the need for this detailed sequencing is not universal.

Apparently, when particular cases were observed of students having difficulty in working out a learning sequence, it was tacitly assumed that this was a universal problem.

Another illustration of this assumption of universality is evident today. Public concern has been aroused throughout the nation over the illiteracy of some high school students and the cry of "Back to Basics" has focused the attention of many schools on the teaching of literacy. Actually, the National Assessment of Educational Progress shows that more than 80 percent of American 17-year-olds can read and comprehend common material. Those who have not learned to read are largely from homes where the parents have had little or no education. The problem of illiteracy is an important one for some schools and some students but it is not a universal problem. The public clamor for attention to "The Basics" has resulted in many places in an obsessive pre-occupation with drill and practice on reading and arithmetic and a neglect of other important areas of instruction, such as science, social studies, literature, art and music.

The research and development community has commonly failed to understand the concerns of teachers and has attributed the lack of attention to research findings and new learning systems by teachers as due to lack of interest in improving education or to the bureaucratic rigidity of the school system. Although some teacher resistance may be due to these factors, most of the failures to apply research are due to lack of mutual appreciation of their problems.

The Function of Research in Education

Research in all fields is an activity seeking to understand certain phenomena, that is to explain each phenomenon in terms of general concepts and principles that are applicable to many particular examples of it. Greater understanding of a phenomenon does not always result in greater control of it, but it furnishes a basis for thinking more clearly about the process and this often leads to devising ways of control. For example, research in meteorology has resulted in increasing understanding of the processes involved in atmospheric disturbances but has not yet resulted in control over tornados and hurricanes. The research has, however, enabled developers to devise more precise forecasting of storms which has aided in the design of protective actions.

Corresponding research on human learning has produced greater understanding not only of conditioning but also of consciously directed learning including such concepts as motivation, reinforcement, sequential practice, and transfer. This understanding has not immediately resulted in more effective teaching methods, instructional materials and devices, but it has furnished a basis for clearer thinking about school learning that helps to give more intelligent direction to teaching.

Needed Research in Science Education

Reviewing contemporary activities in educational research and comparing them with the range of phenomena involved in science education, one is struck by their limited scope. They tend to be focused on school and college programs with a large proportion devoted to psychological analyses of the learners' activities in the classroom. Little attention seems to be given to science learning in such areas as the home, TV viewing, on the job experiences, and the like. In the early '30s, George Stoddard and his colleagues at the University of Iowa showed how much information and misinformation children obtained from watching movies. At the same time, L. L. Thurstone and his group at the University of Chicago showed how powerful a movie could be in creating race prejudice. Some studies are now analyzing the content of TV programs but few attempt to determine empirically their effect upon different types of viewers. Programs like Superman, Spiderman, and the Incredible Hulk are popular with children but little is known as to whether the impact is to increase children's belief in non-natural forces and magical persons or to serve as a relief for them from their feelings of powerlessness because of the limitations imposed by natural forces, while at the same time they do not really believe in magic.

Benjamin Bloom and his students have studied the differences in home environment and child-rearing practices in various kinds of families and shown their relationship to language development in the school. More studies of home and local community environment would help to understand the process of science understanding or misunderstanding among American children and youth.

Few studies are reported on the learning that takes place in museums, in libraries, in nature clubs, and the like. For these voluntary agencies in particular we need to know more about the attitudes children and adults have as they go to museums, libraries, and clubs. What kinds of children coming from what kinds of backgrounds are encouraged to participate in these activities because of interesting things they will learn and what kinds are urged to go in order for parents to shift responsibility for them for a time? We know from the studies of Robert Hess and his colleagues that many middle-class mothers send their children to school saying, "You'll learn to read, write and work with numbers, so you can do things for yourselves. Do everything you can to learn!" He found many mothers in homes of poverty saying to their children, "You've got to go to school. Don't do anything to get into trouble. We have enough trouble at home now." You can imagine the difference in the attitude toward school these two kinds of admonitions will produce. In the first, children are urged to be active and to learn, in the other children are warned to be passive with nothing said about learning. We need to understand the different attitudes learners have and their sources.

Little research has been done on the relation between the public attitude toward science and the achievement of students. From the International Evaluation of Educational Achievement we find that the top 5% of the youth

in each of the thirteen developed nations participating made approximately the same high scores. But, the middle fifty percent of the students in each nation varied widely in their average scores, with Japan leading in science and the U.S. among the top three in reading. The scores in the lowest quarter of the students in the United States exceeded those of the lowest quarter of other countries. Our own national assessment of Educational Progress showed that in 1969-70, American 17-year-olds made higher scores in science than in 1973-74. This might be related to the fact that in 1969-70 the Americans were getting to the moon and the public was enthusiastic about scientific achievements. While four years later, pollution, energy limitations, and environmental degradation were widely publicized and the respect for science had been replaced by blaming science and technology for these problems. One hypothesis is that young people, deeply interested in a subject will learn a great deal about it if there is opportunity regardless of the quality of the school. On the other hand, the middle group of students are strongly influenced in their learning by the public attitude toward the subject. In the United States efforts to help "disadvantaged" children learn were apparently successful in terms of increased achievement of the lowest group in spite of the public attitude.

More research is needed to identify what of science is important for young people to learn who are not planning careers in science or in occupations closely related to science. The follow-up study in 1975 by the American Institute of Research of a sample of persons who were in high school in 1960 and participated in Project Talent are suggestive. These persons were in their 30's in 1975 and were asked about what they remembered, what they used, and what they thought was worth learning in their high school curriculum. With very few exceptions, they replied that the only things they remembered and thought worthwhile in their high school courses were those that they used in their work, like mathematics in engineering, English composition in newspaper reporting, home economics in operating a restaurant, or subjects in which they were deeply interested. Science was listed as a subject of deep interest by very few who were not in occupations utilizing science.

Every subject in the school curriculum is an intellectual enterprise that has amassed a great quantity of material. No one, even the wisest of scientists has in mind all that his science contains. There are a number of basic concepts, a larger number of tested generalizations and principles, and thousands of facts. There are also a good many questions or problems being attached, a fair variety of methods and techniques for conducting inquiries in this science, and many tools and instruments used. Furthermore, each science has developed standards of work and ethics that furnish important guides and constraints on the work of the scientist.

Which of all these things should be learned by whom? This question has not been seriously attacked in the last fifty years. The course content improvement projects supported by the National Science Foundation developed a prospectus of what was deemed important by the scientists giving leadership to the projects but their efforts seem to have been focused on what students needed to learn at each stage of preparation for a career in science or in

science-related occupations. The resulting courses are reported to have been successful in preparing more soundly the students who entered the college and graduate departments of science but they did not attract nor seem to have improved the science understanding of many of the students who were not planning to be scientists.

The relevance of science learning to the experiences, the problems, and the interests of the learners is an important matter not just for utilitarianism in a simplistic sense but because of the nation's need for informed citizens in a world deeply involved in science and technology, and also because things learned are soon forgotten if there is not continued use of the learning in the learner's thoughts, feelings, or actions. The informed citizen cannot know as much as the scientist knows, but he will find some scientific understanding and attitudes essential to his role as a citizen in a democratic society. If this content can be identified, the learning can be accompanied by opportunities to use it outside the classroom and thus transfer of learning is more likely to be assured as well as permanence of learning.

Research needed in science education is not only basic research which results in widely generalizable concepts and principles but also applied research, that is, inquiries focused on particular situations and particular kinds of students, teachers, and institutions, which furnishes information of importance in improving science education in the particular circumstances where efforts to improve science education are being made. For example, most teachers know that the peer group exerts a powerful influence on student learning but the particular science teacher in a particular school needs help in identifying the peer groups in which his or her students are members and what is the content of their influence on science attitudes, interests and understanding. Research may identify in general the relationship of public attitudes toward science and the science learning of students but in a particular community the planning of a comprehensive science program requires knowledge of the various attitudes among members of the community, and how they relate to different kinds of learners. In other words, generalizations indicate significant factors involved in science learning but in the local setting, the educational practitioner needs particular knowledge of these factors and their impact in the local setting. Some of these inquiries may by conducted by the practitioners or by the students themselves. But this is not likely to happen unless researchers furnish technical assistance to show how to conduct this applied research and how to utilize the findings of local inquiries.

This kind of connection between basic research and educational practice helps the practitioner to appreciate the fact that research can be helpful in his or her efforts to improve education, not embodied in development of a particular system for use by teachers or others in the classroom laboratory, home, museum, library, or other places where persons learn. Research often identifies concepts -- ways of thinking about a phenomenon that increase the effectiveness of the practitioner because he or she now observes significant things that were not perceived before or modifies his or her ways of working because the professional role is viewed differently. For example, recent research on "Time on Task" has influenced many teachers to observe the task,

orientation of students in place of noting only disruptive behavior.

Correspondingly, research results can be useful to developers as factors to consider in the design of a learning system, even though the system does not directly embody the research results. For example, research on social influences on learning has affected the design of a computer-managed instructional system although the system is not in itself a social learning system.

The Function of Development in Education

Development in all fields is an activity seeking to design systems that will help to achieve purposes under given constraints. Thus, development in automobile engineering seeks to design cars that will carry passengers without polluting the atmosphere and with minimum gas consumption. As another example, development in the field of law enforcement includes an effort to design a system for police assignment that maximizes the proportion of offenses in which the police have arrived within three minutes and minimizes the number of patrolmen in each precinct. As these two illustrations show, a system may involve a tangible product or it may only involve designing a procedure.

In education, developers produce both tangible products and intangible systems. The development of single concept mini films with sound for science classes is an example of a product which is designed to help individual students understand the meaning and application of important concepts without requiring teacher attention to operation of the projector in a darkened room, nor the winding of a reel and periodic splicing of the film.

The development of an inquiry procedure in introducing a science unit is an example of an intangible system which can be followed by teachers without extended prior training in the use of an inductive approach to science learning.

Needed Developments in Science Education

As in the case of research, reviewing contemporary activities in educational development with the range of phenomena involved in science education, one is struck by their limited scope. They tend to be focused on developing instructional materials and devices for school and college courses. Little attention seems to be given to the development of systems that could be used in the home, and in other community institutions like libraries, museums, and organizations of youth and adults. Only a small amount of development effort seems to be given to the development of systems that do not necessarily require tangible products.

Although teachers report that the problems of class management made individualization difficult, if not impossible, few development efforts are devoted to the design of effective management systems. Although the research of John Goodlad and his students indicate the great potential of continuous progress, learning policies, and the research of Benjamin Bloom and his students demonstrate the great increases in the achievement of the lower half of a class when mastery learning programs are adopted. Only a limited number of development activities

are found that seek to develop systems to make more widely acceptable and effective continuous progress and mastery learning programs.

The explorations of older children teaching younger ones by Mary Kohler and the research on peer group instruction by Herbert Thelen have not been followed by a variety of developments of systems to enhance the effectiveness of programs in which children and youth help to provide learning experiences for others. The same thing is true with regard to the potential contributions of adult volunteers as participants in student science learning.

Development activities are largely carried on without adequate contact with the potential users of the developments. During the past 70 years, a number of technological devices and systems have been invented and developed that appear to offer major contributions to the effectiveness or efficiency of science learning. Among the most widely known are motion pictures, radio, tape recorders, television, high-speed computers, video tapes and video discs. A considerable amount of research has been conducted on several of these devices in seeking to identify the kinds of educational contributions they can make, the results of which have on the whole indicated positive effects. Furthermore, in several cases, wide-spread promotional efforts were made to encourage their adoption in American schools. Yet their utilization is much more limited than was anticipated. In the public schools, educational motion pictures are among the common teaching aids but their use is much more restricted than that of the overhead projector. Most of the other devices have found a significant place in only a small percent of the classrooms.

Reviewing the examples, the use of typewriters by children in the primary grades was tested intensively by Freeman and Wood about 60 years ago. They found that it improved the children's performance in spelling, reading, and handwriting. There was a flurry of adoption of this innovation but within ten years, only a few schools continued the practice.

The use of silent motion pictures was explored 50 years ago, quickly followed by experimentation with sound movies. They were heralded as the means for increasing learning and decreasing the costs of instruction. Today, sound motion pictures occupy an important but modest place among instructional aids, but there is little or no use now of films that are designed to furnish the complete instruction for a course. The use of radio in American schools has followed a very similar pattern after extensive experimentation in the 1930's.

On the other hand, some technological devices, like the overhead projector, caught on quickly and have been adopted very widely. Some innovative systems, like multi-level reading laboratories have also been rapidly accepted and are now widely used. The difference between those innovations that are widely used and those that have not caught on lies in their perceived usefulness by the teacher and their comparative costs.

A typical teacher finds a new technology attractive when it will perform instructional tasks which he or she finds distasteful or boring. Teachers quickly adopted work books and audio tapes for drill and practice work. The also used computers for drill and practice when the school could afford them.

A typical teacher finds a new technology attractive when it will help him or her to perform tasks which are recognized as important but which the teacher has not been able to perform effectively or easily. Most teachers feel a responsibility to provide instruction appropriate to the individual differences among their students but do not see how they can do this when they are responsible for a class of 25 to 35 students. They are attracted to multi-level reading laboratories because they furnish reading materials appropriate for several different levels of reading development. Overhead projectors provide the flexibility of the chalk board to outline, to explain, to illustrate or to direct the student's attention without requiring the teacher to have highly legible handwriting or to turn his or her back to the class. The motion picture is attractive when the teacher wishes to present an event or a process more fully and vividly than he or she is able to do with printed or oral presentations.

There are negative features of innovations that developers also should regognize. Teachers do not believe that most students can learn what the schools and colleges seek to teach without the help of teachers. Hence, when materials are called "self-instructional" or "teacher proof," teachers react unfavorably. Self-instructional materials meet a need of adults but generally they will be used only as practice materials or home work in schools and colleges.

Devices or systems that require extensive training to use effectively or that appear complicated are not likely to be used by most teachers unless they are given the necessary training. The development of easy-to-use film cartridges and tape cassettes greatly increased the use of motion pictures and tape recorders. Prior to that time, motion picture films required threading, rewinding, and sometimes splicing. Audio tapes also required rewinding and were likely to break if not handled expertly.

Another important factor in the use of innovative materials and devices is the cost. About 85 percent of the operating budget of a public school is for the salaries of teachers and other personnel. During the period 1945-1975, only 1½ percent was spent for instructional materials and during the present inflationary period only seven-tenths of one percent of the annual operating budget is being spent for instructional materials. The amount of money available for equipment is no greater. Furthermore, the only way that a new device or new materials can save a significant amount of money is by replacing one or more teachers and thus reducing the size of the school staff. This would also mean increasing class size, and teachers do not generally favor such a policy. Hence, a device or system that is attractive must cost very little.

The foregoing analysis of the reaction of teachers and schools to educational developments is presented to indicate the importance of continuing contact between schools and teachers on the one hand and developers on the other in order that development efforts can be designed so as to be used to improve science education.

Training in the Use of Research and Development

Most educational improvement projects greatly underestimate the amount of training required for a typical potential user to learn how to employ the results of research and development and acquire the confidence needed to undertake the effective use. Several years ago, I served as a consultant to the Hebrew University of Jerusalem and Israel Ministry of Education in projects involving the implementation of the Educational Reform Act of 1968. A considerable effort had been devoted to the development of instructional plans and new materials to aid teachers in following the new science programs which were very similar to the course culture improvement materials developed in the United States.

When the initial implementation projects were instituted in local schools we found that many teachers did not understand the new objectives, did not know how to conduct inquiry learning, did not believe that they could use these new materials effectively and simply tried to teach these new textbooks in the same way they had been using the old ones, that is, asking students to read and remember the material in the books. Before the new programs were implemented in the schools in the ways intended by the developers, about ten times as much had been spent in training and supervising initial efforts as was expended on the research and development of the new courses.

In general, teachers, parents, librarians and others who have a part to play in improving education will not undertake roles that they perceive as new unless they believe the new program will be significantly better than the present one, unless they understand the procedures expected of them, unless they have learned how to carry on new procedures, and unless they feel confident that they can carry them on successfully. Most of them feel comfortable with their present practices and do not want to try something else which might mean failure. The potential contributions research and development activities can make to educational improvement will not be largely realized unless the training requirements are fully met. This involves greater expense and a longer time frame than is usually provided for in the planning and budgeting.

Communication in the Research and Development System

I use the word communication to emphasize the multi-directional channels needed to assist in the improvement of education. It has become popular to refer only to dissemination and diffusion, terms that imply one-way communication, from some centers of knowledge, new ideas, and new materials and devices to a passive audience that should be ready to receive the word from research and development centers. This is a faulty conception. As pointed out earlier, teachers are not passively waiting for things to be diffused to them. They are busy with their tasks and seek help only when they recognize a problem. This is also true of parents, librarians, museum curators and other persons who are consciously or unconsciously stimulating and guiding learning. What is required is a communication network that not only permits but encourages and assists the flow of information from the places where science learning takes

place to research and development centers, and the reverse from development centers to research centers. ERIC provides a useful system to inform researchers and developers but it is only a one-way system.

The leading industrial and commercial research and development centers include consumer research as an important function. An industry that produces office products, for example, conducts studies of the activities in offices, the tasks performed, the problems encountered, the efficiency of the operations, and the like. The results of these studies are used both to guide further applied research in seeking more adequate understanding of the office activities and to identify opportunities for developing new systems or products that can meet the perceived needs of potential customers. Both the applied research divisions and the development divisions attempt to keep in continuing touch with basic research concepts, principles, or instrumentation to furnish suggestions for applied research and for development. Even the basic research divisions try to understand consumer problems as a factor in selecting areas for further investigation.

At the present time, to cite another example, major computer producers are increasing their activities in soft ware development because the research on hardware has reached a point where the tremendous efficiency of computers is not matched by many apparent uses for them. Soft ware development is an undertaking both of applied research and development to design systems employing modern computers that will help to solve important problems consumers recognize or could be helped to perceive. Computer companies are increasing their activities in customer training in order to help them to use computer systems effectively. These companies have established communication networks to aid in their research, both basic and applied, in development, in marketing and in training. Although the processes of education are not so easily dealt with as typical office practices, it seems highly probable that science education could benefit markedly from a better integration of a two-way communication system among all the parts.

The most obvious weakness in the present communication system is the lack of opportunity for easy input by schools, homes, museums, libraries and other places where science learning is going on or could be. The Johnson 1964 Task Force on Education Proposed education laboratories as a means for local education agencies to become an important part of the educational research and development system, and support for them was authorized in Title IV of the Elementary and Secondary Education Act of 1965. However, those that were established were more like R and D Centers than laboratories helping and serving local schools. They often conducted research and developed instructional materials. Rarely did they conceive themselves as representing local educational agencies, helping them identify significant problems, seeking relevant knowledge, ideas, materials and devices to aid in attacking these problems, and communicating research needs to research and development centers. Whether this was due to a misunderstanding of the intentions of the legislation or to a belief that local agencies had no interest in research and development or to the fact that most of the laboratories were staffed by university types oriented to theory rather than school types familiar with practice is not clear.

The need for closer working agreements between practice and research seems to be recognized by the National Science Foundation in another field. The Foundation reported on December 23, 1980:

"The Metropolitan Washington Council of Governments is planning a network of local governments in the mid-Atlantic Region to help solve municipal problems by applying scientific or technological techniques.

Basically, the new network will be designed to enable cities and countries to improve the effectiveness or reduce the cost of specific services such as trash collection or fire and police efforts.

"The network will be a part of a National Innovation Network funded by the National Science Foundation's Division of Intergovernmental Science and Public Technology. The networks consist of groups of government officials, scientists, and technicians who help state and local governments solve day-to-day problems. The NSF program makes use of the scientific and technical expertise of universities, colleges, industries, and research institutions to help solve the cities' problems."

This network of innovation suggests a parallel kind of network for local educational agencies. It should probably not have "innovation" in the title because this term has been used so loosely and with such ill effects that teachers connect the term with poorly planned programs to improve education carried on in inappropriate settings by inadequately trained people to accomplish undefined objectives. Whether a network is established or some other form of cooperation among local agencies to identify and solve educational problems evolves, it is clear from the experiences with efforts to use research and development to improve education that the active involvement of practitioners is essential for widespread implementation.

In Summary

This paper has indicated some of the weaknesses in the present communication system linking educational practitioners with those engaged in research and development. It has suggested that both researchers and developers give attention to the several areas of life where people learn about science. It has asserted that practioners should be viewed as active educators rather than passive recipients of materials and advice from research and development centers, and has identified some of the concerns on which teachers commonly focus their attention. It has also presented some examples of gaps in research and development efforts that limit the comprehensiveness of current knowledge of the systems designed to improve science education. It has pointed out the importance of adequate training for those who are to implement innovations. Finally, it has proposed a reconstruction of the communication system of research, development, communication and practice in science education.